Solderability Specification for Process Printed-Wiring Modules and Plated-Through Holes

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ABSTRACT: This document specifies a standard test method to be used to determine the solderability of printed-wiring modules that are to be soldered by vapor phase reflow soldering, infrared reflow soldering, thermode reflow soldering, hot gas reflow soldering, laser reflow soldering and/or other machine methods suitable for surface mountable devices.

APPLICABILITY: All vendors and users of machine soldering methods involved in determining the solderability of process printed-wiring modules are responsible for meeting the provisions of this document.

STATUS: APPROVED 29-Jun-1990; use VTX SMC for current status.

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1 INTRODUCTION

1.1 PURPOSE

This document specifies a standard test method to be used by both vendor and user to determine the solderability of process printed-wiring modules, with or without surface coatings, that are to be soldered by machine methods which are suitable for through-hole and/or surface mountable processes.

1.2 SCOPE

Two primary test methods are described. In the edge dip test, for surface conductors only, a sample is dipped into the solder bath and the surface conductors are checked for adequate solder retention. In the wave solder test for plated-through holes and surface conductors, a sample board (without components) is processed with the wave solder machine, and the surface conductors and plated-through holes are checked for adequate solder retention.

The solderability determination is made to verify that the printed circuit module manufacturing process and storage have had no adverse effects on the solderability of a printed-wiring module. This is determined by evaluating the ability of those portions of the printed-wiring module normally soldered to be wetted by a new coat of solder.

This specification shall be used as an incoming inspection procedure for preparing and soldering printed-wiring boards, and as an in-process procedure for verifying solderability and for gathering data.

1.2.1 Limitations

This specification shall not be construed as a production procedure for preparing and soldering printed-wiring boards.

1.3 RESPONSIBILITIES

1.3.1 Technical Resource Group

The Technical Resource Group is responsible for the content of this specification, and the members of that group must review and approve all proposed changes.

1.3.2 Digital Organizations

Advanced Manufacturing Technology, Process Quality Assurance, External Board Business, Module Business Groups, PWB Manufacturing Engineering, Module Engineering Groups, and PWB Quality Control are responsible for understanding the requirements set by this specification. These organizations are also responsible for compliance with this specification, and for providing information to keep it current.

1.3.3 Suppliers

Suppliers under contract to produce printed-wiring boards for Digital must comply with the requirements of this specification to the extent defined in the purchase documents.

1.4 DEFINITIONS

Solderability: Property of a metal that allows it to be wetted by molten solder.

Wetting: The formation of a relatively uniform, smooth, unbroken, and adherent film of molten solder or some other liquid on the surface of a panel or board.

Dewetting: A condition that results when the molten solder has coated the surface tested and then receded, leaving irregularly shaped mounts of solder separated by areas covered with a thin solder film, base metal not exposed.

Nonwetting: Occurs when molten solder, or another liquid, contacts a surface, but does not adhere to it. Like dewetting, nonwetting is a symptom of surface contamination.

Wetting Time: The time it takes a solder sample to displace its own weight and return to an equilibrium point on the meniscograph chart.

Wetting Height: The maximum height of the wetting curve above the equilibrium point.

2 EQUIPMENT

The only equipment needed to test solderability is a thermostatically-controlled solder pot large enough to accommodate the largest sample.

- Meniscograph Solderability Tester, by the General Electric Company Ltd.
- Hirst Research Centre, Wembley, Middlesex, England
- Multicor Solders, Cantiague Rock Road, Westbury NY.

Any wave solder system utilized within the corporation can be used for the test.

The solderability tester shall meet the following requirements.

a. The system shall automatically control the rate of immersion, the dwell time, and the rate of withdrawal.

b. It shall be able to keep the board perpendicular to the solder surface.

c. It shall also eliminate wobble, vibration, and all other types of undesired movement.

3 MATERIALS

3.1 SOLDER

The solder shall be 63% tin and 37% lead, as described in Federal Specification QQ-S-571, *Solder, Tin Alloy; Tin-Lead Alloy; and Lead Alloy*; ASTM-63B, *Standard Specification for Solder Metal*; and Digital Purchase Specification, A-PS-4901254-0-0),*Solder, 63/37 Tin-Lead, Virgin Grade, Electronic*. The solder composition shall be analyzed monthly during use for conformance to Table 1. If the amount of any individual contaminant or the total of the contaminants listed exceed the percentage specified, the solder shall be changed. Records containing the results of all analysis and solder bath use shall be maintained. The solder shall be chemically or spectographically analyzed.

Table 1: Unacceptable Contamination Levels (Percent by Weight)

Element	Fed Spec QQ-S-571	Typical New Solder	Unacceptable Contamination
Tin (Sn)	62.5 - 63.5	62.8	62.0
Antimony (Sb)	0.20 - 0.50	0.208	0.500
Copper (Cu)	0.080 max	0.020	0.250
Gold (Au)	–	0.001	0.080
Cadmium (Cd)	0.001 max	0.0015	0.003
Zinc (Zn)	0.005 max	0.002	0.006
Aluminum (Al)	0.005 max	0.003	0.006
Arsenic (As)	0.030 max	0.018	0.035
Iron (Fe)	0.020 max	0.004	0.025
Bismuth (Bi)	0.250	0.019	0.25
Indium (In)	–	0.006	–
Nickel (Ni)	–	0.004	0.010
Silver (Ag)	–	0.006	0.100
Others	0.08	–	0.080

Additionally, the combination of copper, aluminum and gold must not exceed 0.300% by weight. Cadmium and zinc are poisonous and must not be tolerated beyond the limits listed above.

All charts from the solderwave graphic recorder must be archived for historical references.

3.2 FLUX

A nonactivated flux (R), with a nominal composition of 25% by weight of water white gum rosin in a solvent of isopropyl alcohol (99%), shall be used. A mildly activated flux may be used for the wave solder solderability tests only.

3.3 FLUX REMOVER

The flux remover shall be either isopropyl alcohol or aqueous cleaner material, as used in manufacturing plants.

4 CRITERIA

Solderability of both surface conductors and plated-through holes shall be tested by either the edge dip method or the wave solder method. For acceptance, the surface conductor criterion Section 4.1 must be met, and any one of the plated-through hole criteria Section 4.2 must be met.

This testing must be performed by the user at incoming inspection, or by the vendor prior to shipment. If performed prior to shipment, the vendor must include with the shipment a certificate of compliance to the specification.

This testing may be performed by the user at an in-process station, for the purposes of verifying solderability and gathering historical data.

For visual examination, use a magnification of at least 10X at a focal length of 10 inches for solder inspection; 30X magnification shall be used for referee examination.

4.1 SURFACE CONDUCTORS

4.1.1 Acceptance Criteria

The criterion for acceptable solderability is that at least 95% of the surface being tested (a particular pad, run, and so forth) shall exhibit good wetting. The balance of the surface may contain small pin holes, dewetted areas, and rough spots, provided such defects are not concentrated in one area. Features shall not be grouped together for the purpose of this calculation.

For surface mount footprint patterns of less than 20 mil pitch, 100% of the critical joint area must exhibit good wetting of a new solder coat.

Meniscograph criteria shall be a wetting time of not greater than 1.5 seconds, with a wetting height greater than the equilibrium point of the sample curve.

4.1.2 Exception

Areas contacted by fixtures shall not be evaluated.

4.2 PLATED-THROUGH HOLES

4.2.1 Acceptance Criteria

Profile views of acceptable and unacceptable conditions are illustrated in Figure 1 and Figure 2, respectively. The plated-through holes shall be considered solderable if they meet one or more of the following criteria.

a. The hole walls shall be considered solderable if they match the acceptable conditions illustrated in Figure 1.

b. The specimen has soldered successfully if solder has risen in all the plated-through holes and if the solder has wetted the land area (pad) at the top of the hole.

c. The solder need not have plugged the hole, but the wall of the hole shall be fully wetted.

d. Partially filled holes are acceptable under the following condition. The solder in partially filled holes must exhibit a contact angle less than 90° relative to the hole wall.

NOTE

Each hole shall exhibit some form of wetting. For the holes to be 95% wetted implies that 95% of each hole is wetted by solder (not that 95% of the holes on the board are filled and 5% are completely without solder).

Figure 1: Plated-Through Holes - Wetted Acceptably

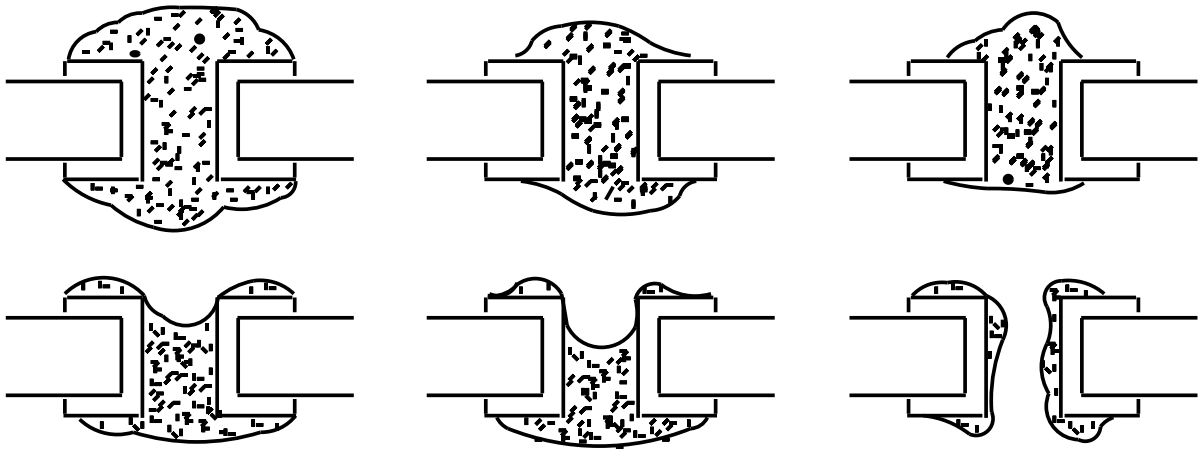
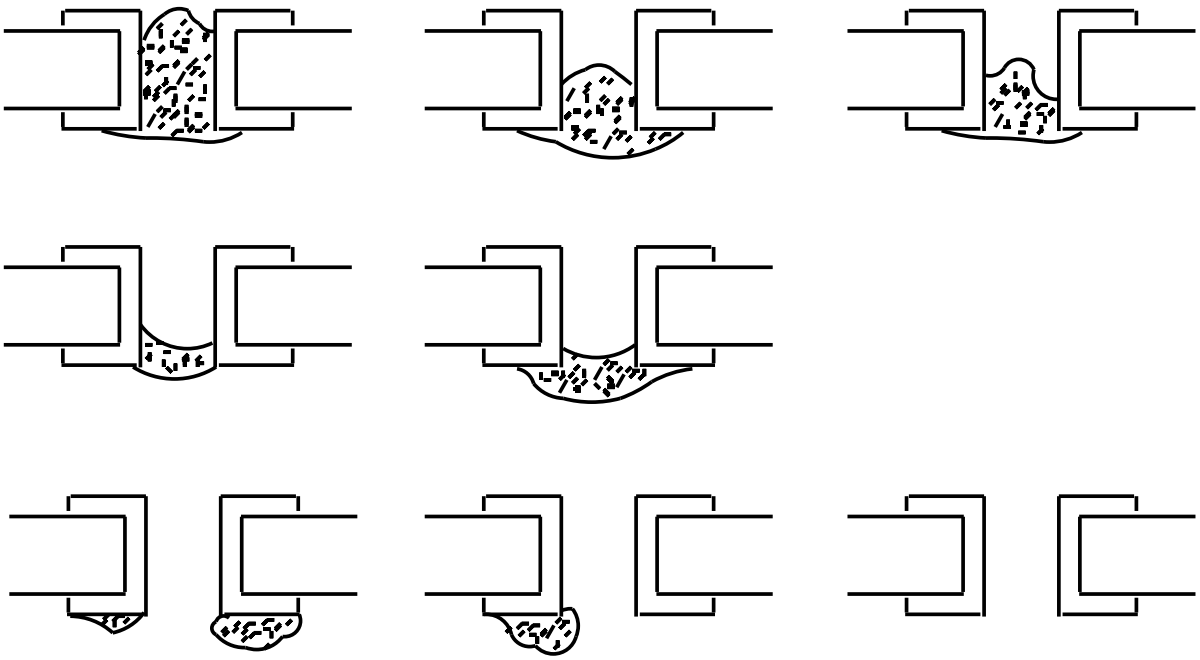


Figure 2: Plated-Through Holes - Wetted Unacceptably



4.2.2 Exceptions

Only those plated-through holes that are at least 0.2 inch from any surface, or from any fixturing structure that supports the specimen during the test, will be evaluated.

Some modules have solder resist intentionally placed in the plated-through holes. These holes need not meet the solderability requirements.

NOTE

Modules with a dry film soldermask must be checked after application to ensure adhesion of the mask and non-migration of the solder from etch to etch under the film. This can be performed with either a float test or a wave solder process.

5 TEST METHODS

5.1 EDGE DIP TEST

5.1.1 Specimen Preparation

The test specimen shall be a representative portion of the printed-wiring board being tested, such that an immersion depth of 3 mm is possible on the Meniscograph Solderability Tester, or equivalent. The minimum size of the coupon shall be 1/2 ± 1/8 inch wide by 1 ± 1/8 inch long.

The test sample shall be representative of the lot being tested. When this test is to be used as a criterion for material acceptance, the number of test specimens shall be defined by agreement between the supplier and the user.

5.1.2 Accelerated Aging

If the product is to be stored and used when it is more than six months old, the samples shall be accelerated aged. The test specimen shall be steam aged between 8 and 16 hours per A-SP-ELMF542-00-0, and thoroughly dried and exposed to a simulated process environment prior to solderability testing.

5.1.3 Meniscograph Test Procedures

The test samples shall be dipped, to the full depth to be soldered, for 5 to 10 seconds in the flux described in subhead 3.2. After withdrawal from the flux, the sample shall be allowed to drain vertically for 60 seconds. At the end of this time, the edge shall be blotted. The following test shall then be performed not less than one minute, and not more than five minutes, after blotting.

The molten solder shall initially be stirred with a clean, stainless steel paddle to ensure that the solder is of a uniform composition and at a temperature of 245° ± 5° (473° ± 9°F). Dross and burned flux shall be completely removed from the surface of the molten solder immediately prior to dipping. After fluxing and draining, the sample shall be dipped edgewise into the molten solder to a depth of 3 mm. The insertion and withdrawal rates shall be 25 ± 6 mm per second. The dwell time in the molten solder shall be 3.0 seconds ± 0.5 second. After withdrawal, the solder shall be allowed to solidify by air cooling while the board is maintained in a vertical position.

5.2 WAVE SOLDER TEST (For Through-hole PWBs That Will Be Wave Soldered)

The test samples shall be a production printed board representative of the lot being tested. When this test is to be used as a criterion for material acceptance, the number of test specimens shall be defined by agreement between the supplier and the user.

5.2.1 Specimen Preparation

Specimens shall be fixtured, as much as is practical, to be representative of the production setup, without components inserted.

The printed boards shall be tested in the "as received" condition from the vendor, and care shall be exercised to prevent contamination (by grease, perspiration, and so on) of the surface to be tested.

The test samples shall be flux coated before proceeding with the solder application. Flux shall be applied with the existing equipment fluxing system. There shall be no excess flux on the bottom of the board.

5.2.2 Test Procedures

Solder shall be applied according to the following test procedures.

1. Wave solder the specimen according to the process agreed to between user and vendor. The application of solder shall meet the requirements of the Hollis Wave Solder System.
2. The following parameters must be established and noted: board fixturing (if required), conveyor speed, flux applicator, preheater, solder unit with or without oil intermix, machine process controls, incline board preheat temperature, solder temperature.
3. The duration of contact shall not exceed two seconds.

After the solder has solidified and cooled, the flux shall be removed from the specimens to facilitate inspection. The flux removing chemical is specified in Section 3.3.

5.3 ASSEMBLED BOARD

As an alternative to the bare printed-wiring board wave solder test, a module can also be assembled with components and then wave-soldered. For this test, solder requirements shall meet the criteria of heading 4 and subordinate subheads, and the solderability parts of *DEC STD 176-0 Printed-Wiring Board Acceptance Criteria.*

6 PREBAKING

The occurrence of outgassing, which may result in blowholes, may be reduced by baking the printed board prior to soldering. This will eliminate surface moisture or solvents. The bake cycle is 185°F for two hours. Refer to Technical Bulletin No. 3, *Pre-baking PTH Boards*.

Measling, blistering, or delamination may be reduced, or eliminated by performing a different type of bake. This bake cycle should be 240°F for four hours minimum, depending on the humidity conditions of the environment. Refer to Technical Bulletin No.131-B, *Multilayer Module Baking Process*, for the exact parameters and procedures.

NOTE

The bake cycle at high temperature must be done with only bare boards; components cannot be mounted on the boards prior to this process.

Other factors, such as conveyor speeds, solder temperature, contamination content, and so on, may also be involved in producing defects, and should by analyzed if problems occur.

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00176-00	*DEC STD 176-0 Printed-Wiring Board Acceptance Criteria*
EL-MF542-00	*Accelerated Aging Specification for Module-Mountable Components (Through-Hole and Surface Mount)*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

A.2 Other Digital Documents

Document Number	Document Title
A-II-1400011-0-01	*Copper-clad Laminate Inspection Procedure*
A-PS-4901254-0-0	*Solder, 63/37 Tin-Lead, Virgin Grade, Electronic*
TECH. BULLETIN 131-B	*Multilayer Module Baking Process*
TECH. BULLETIN 3	*Pre-baking PTH Boards*

A.3 Other Documents

Document Number	Document Title
ASTM-63B	*Standard Specification for Solder Metal*
IPC-S-804	*Solderability Test Methods for Printed-wiring Boards*
IPC-S-815	*General Requirements for Soldering of Electrical Connections and Printed Board Assemblies*
IPC-T-50	*Terms and Definitions*
QQ-S-571	*Solder, Tin Alloy: Tin-lead Alloy; and Lead Alloy*

A.4 Ordering Information

Following are the sources for documents not available from Standards and Methods Control.

- American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103
- Central Specification Control Systems
  (NRO-5/M2), any Microfilm Reference File, or the SPOC System
- Institute of Printed Circuits
  3451 Church St., Evanston, IL 60203

- Naval Publications and Forms Center
  5801 Tabor Ave., Philadelphia, PA 19120
  telephone (215) 697-3321
- Technical Bulletins No. 131-B and No. 3 may be referenced at your local Digital library.

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